UNCLEAN HAND DETECTION MACHINE USING VISION SENSOR

RAWAIDA BINTI JAAFAR

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Faculty of Electrical & Electronics Engineering
Universiti Malaysia Pahang

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ABSTRACT

This project is in the collaboration with the Department of Microbiology and Parasitology of Medical campus USM. This project will deliver an automated hand wash screening audit system using a vision system. The amount of the hand wash screening audit is done manually by an expert to monitor the hands under ultraviolet light once it's been washed. This project is proposed to automate this hand wash screening audit by using a vision system. By using the vision system, the hand wash screening audit will be done automatically and accurately without the attendance of human expert to detect the unclean areas of the hands. The vision system is designed to increase accuracy to detect the unclean areas of washed hands after using the GLO GERM. GLO GERM acts as stimulated germs. This system will not only detect the unclean areas, but will also estimate the percentage of the unclean areas which will be used as further analysis of the efficiency of the system. However, we need to build the hand wash prototype using ultraviolet light and a camera that is connected to the computer to process and display the results of the hand wash screening audit using image processing software. In the image processing technique, we used hand detection to detect the areas of the palm of the hand and stain on palm detection to detect the unclean areas of the hands using HSV thresholding and RGB masking techniques. We detected the areas of unclean hands which dictated by the colored that has GLO GERM stains. The GUI will show the captured image and detected unclean area image and also the percentage of the unclean areas of the hands. The GUI will notify the decision of clean or unclean based on the percentage of unclean areas. This system design is efficient and commercial in the market especially in HUSM for requirements of health care applications. Other hospitals or industries whom hand hygiene is very crucial are potential buyers.

ABSTRAK

Projek ini adalah dengan kerjasama dengan Jabatan Mikrobiologi dan Parasitologi Perubatan kampus USM. Projek ini akan melaksanakan sistem pemeriksaan audit untuk pembasuhan tangan secara automatik yang menggunakan sistem penglihatan. Jumlah pemeriksaan audit untuk pembasuhan tangan yang dilakukan secara manual oleh seorang pakar pengaudit untuk memantau tangan di bawah cahaya ultraungu sebaik sahaja ia telah dibasuh. Projek ini dicadangkan untuk mengautomasikan mencuci tangan pemeriksaan audit dengan menggunakan sistem penglihatan. Dengan menggunakan sistem penglihatan, pemeriksaan audit untuk pembasuhan tangan akan dilakukan secara automatik dan tepat tanpa kehadiran pakar manusia untuk mengesan kawasan tapak tangan yang tidak bersih. Sistem penglihatan direka untuk meningkatkan ketepatan untuk mengesan kawasan tapak tangan yang tidak bersih yang sudah dibasuh selepas menggunakan GLO GERM. GLO GERM bertindak sebagai kuman dirangsang. Sistem ini bukan sahaja akan mengesan kawasan yang tidak bersih, tetapi juga akan menganggarkan peratusan kawasan yang tidak bersih yang akan digunakan sebagai analisis kecekapan sistem. Walau bagaimanapun, kita perlu membina prototaip mengesan tangan dengan menggunakan cahaya ultraungu dan kamera yang disambungkan ke komputer untuk memproses dan memaparkan keputusan audit pemeriksaan pembasuhan tangan menggunakan perisian pemprosesan imej. Dalam teknik pemprosesan imej, kita menggunakan pengesanan tangan untuk mengesan kawasan tapak tangan dan kotor kepada pengesanan pada tapak tangan untuk mengesan kawasan yang tidak bersih tangan yang menggunakan teknik pengambangan HSV dan RGB. Kami mengesan kawasan tangan yang tidak bersih yang ditentukan oleh berwarna yang mempunyai kotoran GLO GERM. GUI akan menunjukkan imej yang ditangkap dan dikesan imej kawasan yang tidak bersih dan juga peratusan kawasan tangan yang tidak bersih. GUI akan memberitahu keputusan berasaskan bersih atau tidak bersih itu pada peratusan kawasan yang tidak bersih. Reka bentuk sistem ini adalah cekap dan komersil di pasaran terutama di HUSM untuk keperluan aplikasi penjagaan kesihatan. Hospital-hospital lain atau industri yang mementingkan kebersihan tangan amat penting sebagai tumpuan bakal pembeli bagi produk ini.

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LIST OF ABBREVIATIONS

RGB	Red Green Blue
HSV	Hue, Saturation and Value
MATLAB	Matrix Laboratory
2-D	Two Dimensions
3D	Three Dimensions
WHO	World Health Organisations
CDS	Centres for Disease Control
HAI	Hospital-Acquired Infection
NGO	Non-Governmental Organisations
CD	Compact Disk
GUI	Graphical User Interface
LCD	Liquid Crystal Display
CRT	Cathode Ray Tube
HD	High Definition
USB	Universal Serial Bus
PCB	Printed Circuit Board
CE	Certification Experts
ROI	Region Of Interest
PC	Personal Computer
PVC	Polyvinyl Chloride
PMMA	Poly Methyl Methacrylate
CITReX	Creation, Innovation, Technology and Research Exposition
i-ENVEX	International Engineering Invention & Innovation Exhibition
MIYIO	Malaysian International Young Inventors Olympiad

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CHAPTER 1

INTRODUCTION

1.1 Overview

Hands are the source of many infections especially Nosocomial infection. A Nosocomial infection also known as a hospital-acquired infection (HAI), is an infection whose development is favored by a hospital environment, such as one acquired by a patient during a hospital visit or one developing among hospital staff. Such infections include fungal and bacterial infections and are aggravated by the reduced resistance of individual patients. Due to this issue, hand hygiene is essential to prevent cross-infection from the hospital or infection of health care facilities.

Hand hygiene is one of the areas in the field of infection control. It is simple and the best way to prevent infection and illness. The general indicators for hand hygiene are when hands are visibly soiled or not soiled before and after a healthcare worker's contact with the patient’s skin.

Clean hands prevent infections. Keeping a clean hands can prevents illness at home, at school, and at work. Hand hygiene practices are key prevention measures in healthcare settings, in daycare facilities, in schools and public institutions, and for the safety of our food. In healthcare settings, hand hygiene can prevent potentially fatal infections from spreading from patient to patient and from patient to healthcare worker and vice-versa.

Infectious complications are frequently found among critically ill neonates. Hand hygiene is the leading measure to prevent healthcare-associated infections, but poor compliance has been repeatedly documented, including in the neonatal setting. Hand hygiene promotion requires a complex approach that should consider personal factors affecting health care workers' attitudes [1].

The World Hand Hygiene Day is celebrated annually on May 5th by the World Health Organization (WHO) and some NGOs. The event is to CDC and other partners to encourage health care providers to promote and practice good hand hygiene measures to reduce the risk of infection among patients. A Centers for Disease Control (CDC) has developed several hand hygiene resources for patients and healthcare providers. It works to protect public health and safety by providing information to enhance health decisions, and it promotes health through partnerships with state health departments and other organizations. The CDC focus national attention on developing and applying disease prevention and control (especially infectious diseases and foodborne pathogens and other microbial infections), environmental health, occupational safety and health, health promotion, injury prevention and education activities designed to improve the health of the people of the United States [2].

According to a survey conducted by the U.S. Centers for disease control and prevention, forty million Americans contract illnesses every year due to the bacteria on the hands and around eighty thousand of them die. Looking at these alarming hand washing facts, one can conclude that it is very important to keep one's hands thoroughly washed and clean at all times, to prevent illnesses and infectious diseases [3].

Using a proper hand washing technique is very imperative, especially for people who work in the health and hospitality industry, where germ transmission is much more likely to happen. By thoroughly washing hands, a person is actually contributing to the prevention of the spread of diseases. Researchers have shown that if the hands are washed properly, then incidences of respiratory diseases as well as digestive diseases which are infectious can go down, which in turn can save a lot of lives. Thus, it becomes the duty of each and every person to learn from these

hand washing facts and keep their hands properly clean and hygienic to lead a disease free and healthy life, both for the person and for the people who come in contact with the person.

Normally, the decision of hand screening audit refers to the Figure 1.1.1 below for the clean or unclean hand. The figure shows a frequently missed areas of the stains in the palm of the hand. This figure is taken from the Ministry of Health Malaysia. Based on this figure, it separates to the 2 types, which is red color refers to the most frequently missed areas while the green color refers to the not missed areas while washing the hands [4].

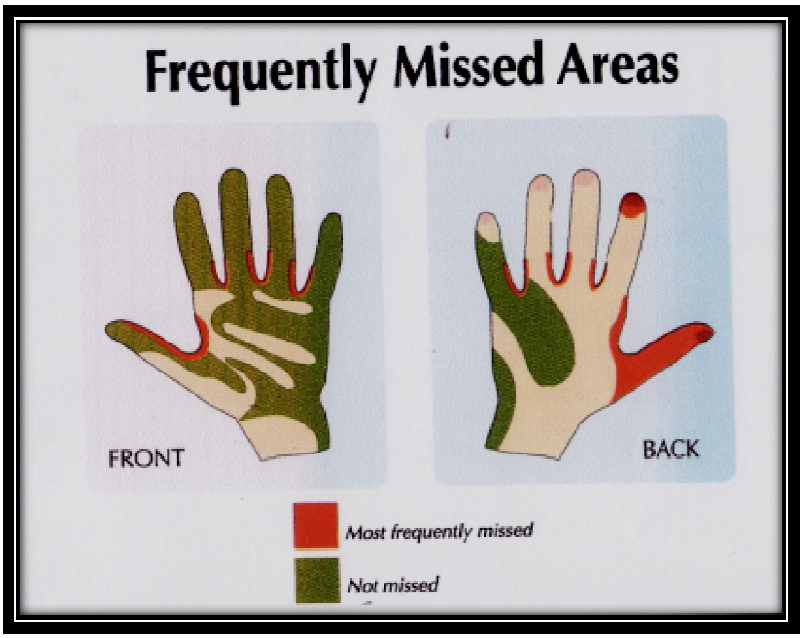

Figure 1.1.1: Frequently Missed Areas

To reduce the risk of infections, currently the hand wash screening audit was done manually. The goal is to calculate the percentage of unclean area of the washed hands. The interaction between the natural tool that is our hand and modern tools such as computer, the system become can a very powerful tool.

1.2 Problem Statement

As required by the Department of Microbiology and Parasitology of Medical campus USM, this project will deliver an automated hand wash screening system using a vision system. Currently the hand wash screening audit is done manually by an expert to monitor the hand under ultraviolet light once it's been washed. Hence, there is a need for more human experts to conduct the screening manually.

This project is proposed to automate the hand wash screening audit by using a vision system. The vision system is designed to increase accuracy to detect the unclean area of washed hands. This system will not only detect the unclean area, but will also calculate the percentage of the unclean area which will be used as further analysis of the efficiency of the system.

However, we need to build the hand wash prototype using ultraviolet light and a camera that is connected to the computer to process and display the results of hand wash screening.

1.3 Objectives

The objectives that we are trying to reach through this project are:-

1. To develop the hand wash screening system using vision system to automatically detect the unclean hands.

2. To develop prototype of hand wash screening using ultraviolet light and camera.

3. To develop the software using MATLAB that will automatically detect the hand and unclean area using image processing technique.

1.4 Scopes of Project

This project it is designed to meet the following scopes:-

1. MATLAB will be used as the software which will be connected to the hand wash prototype to display the captured image and its results.

2. Data images are specific to the image of hands that being washed after being stained by GLO GERM under the ultraviolet light.

1.5 Significance and Rational of Study

The significance of this project is to increase hygiene among the hospital staff. At the hospital, hand wash screening audit is important to reduce the number of germs transmitted to the patients by the hand contacts between staffs and patients thoroughly touch. The audit is done by staining their hands with GLO GERM and then washing their hands. The hand wash technique efficiently can be monitored manually by an expert staff under the ultraviolet light.

By using the vision system, the hand wash screening audit will be done automatically and accurately without the attendance of human expert to detect the unclean hand. The hand image that is being stained with GLO GERM and then washed will be captured from the hand wash prototype under the ultraviolet light. The missed area of the washed hand will show the traces of GLO GERM in its original colors. The software of the system will detect the percentage of unclean area and calculate its percentage to decide whether the hand is clean or not.

1.6 Dissertation Organization

This thesis consists of 5 chapters: Introduction, Literature Review, Methodology, Result and Discussion, and the last chapter are a Conclusion and Recommendations of the project. The organization is as below:-

Chapter 1 introduces the overview of this project, objectives, problem statements, scopes of the project and the significance of the study.

Chapter 2 contains the literature review on various technical papers and researches related to the modeling and various hand detection techniques.

Chapter 3 contains an explanation of the methodology of this project. In this chapter, each step is the process flow including hardware and software of the hand wash prototype will be explained.

Chapter 4 will discuss and analyze the results of the system design. This section also contains product performance, product verification and cost comparison between available product in the market and estimate product costing.

Chapter 5 will conclude the project followed by the recommendations and product commercial potentialities for future enhancement of the 'Unclean Hand Detection Machine using Vision Sensor' project.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, some studies related to the project including previous researches will be discussed. The literature review is an investigation we make for project technique which it explains with theories about how to operate the project.

To make our project functioning like it should be, the first thing that we must know is about the technique that contain in entire experiments that we used. Here, in chapter 2 'Literature Review', we put several techniques that popular and very important for our project and is used in many papers. We also studied about their characteristics and also their purposes. Besides that, we also put a lot of sample papers since we used as my references for my project.

2.2 Finger Detection Technique

In the paper entitled Finger Detection for Sign Language Recognition by Ravikiran J et.al [5], the author introduces an efficient and fast algorithm for identification of the number of fingers opened in a gesture representing an alphabet of the American Sign Language. This paper presents a special-purpose image processing that we have developed to recognize signs from the American Sign Language with high accuracy. A significant contribution of this result is that it does

not require the person making the signs to use any artificial gloves or markers. Finger detection is accomplished based on the concept of Boundary Tracing and Finger Tip Detection. It has focused primarily on identifying the number of fingers opened in a gestured representing an alphabet of the American Sign Language. Knowing the number of fingers open, it is possible to identify reliably the gesture as an alphabet belonging to a class of the gesture which has fingers open. These papers present a robust and efficient technique for finger detection, there are three main phases of processing, that are Edge Detection, Clipping and Boundary Tracing. Edge Detection is a phenomenon of identifying points in a digital image at which the image brightness changes sharply or, more formally, has discontinuities. While, clipping is used to cut a section through the data (image) currently being rendered. The image contents that pertain to the area of interest are retained after clipping. Lastly, Boundary Tracing. This phase of the algorithm is the heart of processing. The edge detected image which is clipped serves as the input to this phase. The output is the traced image where the trace-points are highlighted in blue and the points where the finger tip is detected are highlighted in red. This algorithm designed is a simple, efficient and robust method to locate finger tips and enables us to identify a class of hand gestures belonging to the American Sign Language which have fingers open. The accuracy obtained in this work is sufficient for the purposes of converting signs language to text and speech since a dictionary can be used to correct any spelling errors resulting from the 5% error in our gesture recognition algorithm.

2.3 Texture Extraction using the Palmprint Biometrics Technique

In the paper entitled Combined Shape and Texture Information for Palm print Biometrics by Rafal Kozik and Michal Choras [6], is presented texture feature extraction is merged with polygon-shape palm geometry features. Polygon shape detection is based on the detected characteristic hand geometry points. The rich texture feature information of the human palm print places it as one of the powerful means in personal identification and authentication. In general palm print features can be divided into three different categories, first is point features, which include minutiae features from ridges existing in the palm, and delta point features, from

delta regions found in the finger-root region. Second is line features, which include the three relevant palm print principal lines, due to flexing the hand and wrist in the palm, and other wrinkle lines and curves (thin and irregular). Lastly is a texture feature of the skin. Palm print texture feature extraction methods based on the variance value calculated for each of the image blocks, Haar Wavelets and PCA are presented. Variance value local features used before palm texture feature extraction preprocessing is performed. After presented preprocessing procedure the palm print is divided into several blocks and the variable value is calculated in each of the blocks. Variant values computed in each block are stored in a feature vector. Its dimension depends on the numbers of blocks. Harr wavelet gives good results for edge detection. Wavelet distribution of the image is used to calculate palmprint features and to achieve better features separation in high and low frequency information. The authors showed that palmprint featured may be considered as very promising biometric modality which can be used in high-security human identification systems. The authors also tested and evaluated the presented features and showed that experimental results proved that adding palmprint geometry (shape) information increased system efficiency.

2.4 Contour Tracking using Hand Image Interpretation Technique

In the paper entitled Hand Image Interpretation based on Double Active Contour Tracking by Wlodzimierz Kasprzak and Piotr Skrzynski [7], has proposed an approach to hand sign interpretation in image that is based on active contour tracking. The author decomposed their approach into five steps. First is color-based skin pixel detection. Second is double hand contour detection. Third is the localization of fingers and the palm (the hand description generation). Fourth, the detection of a final position (with respect to considered signs), and finally, the fifth is the interpretation of a single position or a sequence of positions in terms of a hand sign. The goal of this paper is to interpret the recognized hand in terms of commands given to the machine by a human operator. The creation of such image recognition system requires solutions in several image analysis area: color-based region-of-interest detection [4], hand contour detection, 3-D hand instance generation and

interpretation. The author is interested in man-machine communication aspects, assuming that a single view is available, the hand can be freely oriented in space, while finger positions can also be different. The current hand instance is generated out from the hand contour description in three steps. The center of mass and other specific boundary points of the inner contour determine the location and size of the palm. The fingers are detected on the base of the locations of finger tips with respect to the projection point of the center of mass onto the palm rectangle side, opposite to the tips. The thumb is detected among the points if its tip projection onto the palm rectangle is located below the mass center point. As a result, the author has experimentally verified that our hand description can be in a unique way be transformed into a set of 21 signs. If the fingers are well separated one from the other then the first active contour is processing in-between them. The second contour then matches the boundary palm area f the hand. Otherwise, both contours are similar, except of the visible thumb position.

2.5 ROI (Region of Interest) Acquisition Technique

In the paper entitled Real-time ROI Acquisition for Unsupervised and Touch-less Palmprint by Yi Feng et.al [8], proposes a novel method to acquire the ROI (Region of interest) of unsupervised and touch-less palmprint captured from a web camera in real-time. It is very important to design a novel system to process the touch-less and unsupervised hand image. That is because most current palm print recognition systems have a complex device for controlling the light, background, and hand position. These systems are much larger than fingerprint recognition system. The users must put their hand in the semi-enclosed box, on the sensor or a plate with pegs. It makes the user very uncomfortable during identification and causes sanitary issue in the public areas. In this paper, the authors described the development of a real-time ROI acquisition for unsupervised and touch-less palmprint system which will be used in palmprint recognition. It will not require the user's hand touch any platform. The users just need to put their hand in front of a sensor in the unconstrained scenes. They can open their hand, close their hand or pose others in a natural manner. This system is also robust enough to work in various lightning and

cluster background. After that, the authors proposed a novel method to find the key point in the skin area coarsely quickly, and then use the shape context descriptor of the key points to verify whether the point is the key point of a hand. This strategy is fully satisfactory, in terms of both efficiency and accuracy. Lastly the authors get the location of ROI and acquire ROI of palmprint for recognition with the key point and original hand image. Owing to the system's requirement of real-time, we must use a kind of quick and effective method to discard the non-hand image and segment the target area. So, the author chose Viola and Jones [6]. The goal of hand detection process is to discriminate whether the image contains a hand. This process should be a fast as possible, so as to be able to process the entire frame in real time. Viola and Jones [6] originally proposed the cascade of boosting classifiers as a real-time general object detector and applied it to face detection. They showed that the system works quite well at various scales and with different backgrounds under various illumination conditions. The author applies Lienhart's methods, as implemented in the OpenCV, Open Computer Vision Library (2006), to the hand detection problem. It processes the image captured by a web camera in real-time and achieves promising result. It is robust to the changes of hand poses and work well under cluster background.

2.6 Hand Tracking uses Stereo Analysis Technique

The paper entitled Evolution of hand tracking algorithms to MirrorTrack by Yannick Verdiè [9], proposes the hand tracking technique that has evolved a lot during the last years from one camera solutions to 3D solution, offering users an improved experience. This paper describes the main methods used in hand tracking algorithms based on single camera and their limits, the meanings of touch and the advantages and the particularities of this newly rehabilitated sense and how single camera algorithms have been improved by stereo analysis (3D). Stereo Analysis was used in various applications from hand to body tracking to meteorological satellite data process [8]. Stereo analysis uses more than one camera. To overcome the location issue inherent to single camera usage, as well as to implement a robust system using touch sense, Stereo analysis takes advantage of multi field of vision

created by several cameras. Stereo analysis uses the same algorithms. Stereo analysis is a very promising area which still needs research efforts, especially the very convenient solution of MirrorTrack. This paper highlights the main techniques aiming at detecting and tracking fingertips that have been published. This paper also focused on the definition of fingertips location. The main advantage of using a single camera is that users could easily use their own camera or webcam. It is also allows a single common domestic computer to handle the algorithm. The goals of fingertips location are to localize the fingertips of the hand. MirrorTrack seems to be an interesting solution to analyze as it is both very easy to implement and providing a good user's experience by using a completely new method. MirrorTrack, as will be demonstrated at the end of this paper, takes advantage of existing algorithms while introducing particularities that make it a very powerful solution. It is very promising and interesting area of research in the coming months

2.7 Feature Extraction using Hand Geometry and Palmprint Verification System Technique

In the paper entitled A Single-sensor Hand Geometry and Palmprint Verification System by Michael Goh Kah Ong et.al [10], they proposed a combination of hand geometry and palmprint verification system is being developed. First, the hand geometry verification system performs the feature extraction to obtain the geometry verification system performs the feature extraction to obtain the geometrical information of the fingers and palm. Second, the region of interest (ROI) is detected and cropped by the palmprint verification system. This ROI acts as the base for palmprint feature extraction by using Linear Discriminator Analysis (LDA). Lastly, the matching scores of the two individual classifiers is fused by several fusion algorithms namely sum rule, weighted sum rule and Support Vector Machine (SVM). During the image acquiring process, the users are required to stretch their fingers and put their palm straight on the platform of the scanner. The hand images acquired is in 256 RGB colors (8 bits per channel) format. The three color components are important in the preprocessing stage as it can distinguish the background, finger nails, rings and the shadow from the hand image. This clear distinction helps to trace

the hand image more accurately and reliably. The results of the fusion algorithms are being compared with the outcomes of the outcomes of the individual palm and hand geometry classifiers. In this paper, the authors also described a bimodal biometric verification system based on hand geometry and palmprint modalities. This system uses a natural fusion approach as both of the biometric features originate from the same part of the body. In this paper, a prototype of the bimodal biometrics system by using single sensor has been developed.

2.8 Palmprint and Knuckles Print Recognition Technique

In the paper entitled Bimodal Palmprint and Knuckle Print Recognition System by Connie Tee et.al [11], is proposing an innovative contract-less palm print and knuckle print recognition system. The authors explored an alternative way to utilize palm print and knuckle print features for biometric recognition. Palm print is referred to as line texture, which contains principal lines, wrinkles and ridges on the inner surface of the palm. On the other hand, knuckle print is denoted as the flexion lines on the inner skin of the knuckles of the fingers. This paper presented a novel palm print and knuckle print tracking approach to automatically detect and capture these features from the low resolution video stream for recognition. They utilized the knuckles print from four fingers, namely the pointed, middle, index and little fingers. This paper presented a low resolution contact-less palm print and knuckle print recognition system. The proposed contract-less palm print recognition system offers several advantages like flexibility and user-friendliness. The authors proposed a novel hand tracking algorithm to automatically detect and locate the ROIs of the palm print and knuckles print. The proposed algorithm works well under semi-controlled environment. Although the proposed system works satisfactory in semi-controlled environment, further investigation should be conducted to verify its effectiveness under other types of open-environments. Besides, more users should be included into the database to test its feasibility to be used in medium to large organizations.

2.9 Conclusion for All Listed Techniques

The finger detection technique is focused for American Sign Language. This system does not require the hand to be perfectly aligned to the camera or use any special markers or input gloves on the hand.

While, texture feature extraction using polygon shape detection technique is merged with polygon-shape palm geometry features. Polygon shape detection is based on the detected characteristic hand geometry points.

Hand tracking using Stereo Analysis technique has evolved a lot during the last years from one camera solutions to 3D solutions, offering users an improved experience. Stereo analysis is a very promising area which still needs research efforts, especially the very convenient solution of MirrorTrack.

Hence, technique of feature extraction using hand geometry and palm print verification system uses a natural fusion approach as both of the biometric features originate from the same part of the body. Further works are planned to do robust testing for unbalanced cases, experiments comparison of different kind of fusions approach such as neural-network and fuzzy integral, and increase the database size.

Palm print and knuckle print recognition system technique approach to automatically detect and capture these features are extracted from the low resolution video stream. Contact-less palm print recognition system offers several advantages like flexibility and user-friendliness. Novel hand tracking algorithm works well under semi-controlled environment.

Last but not least, based on the both techniques above, contour tracking and ROI (region of interest) acquisition techniques are more suitable and preferable to be implemented in this project. It is because contour tracking technique is progressing in-between the fingers and then matching the boundary palm area of the hand. While, the ROI (region of interest) acquisition technique can analyze the difference of connectivity between the foreground (hand area) and the background (non-hand area), which is not stable because of a hand pose changing.